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GROWTH AND YIELD ATTRIBUTE OF OKRA (ABELMOSCHUS ESCULENTUS L.) UNDER THE APPLICATION OF BIO AND CHEMICAL FERTILIZERS EITHER ALONE OR IN COMBINATION

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ABSTRACT

The effect of Bio and Organic fertilizers on growth and yield of Okra (Abelmoschus esculentus L.) was evaluated during late zaid season to early kharif season in the year 2015 at Patanjali Gramudyog Nyas (Haridwar district) Uttarakhand, India. Two type of seeds variety (Open pollinated and Hybrid) were taken for this study. The field experiment was laid out in Randomized Block Design (RBD) with four treatments including one control having three replications each. The treatment T1 received 100 % Chemical fertilizer @ of 75 kg/acre, in T2 and T3 the Chemical fertilizers was gradually replaced by Biofertilizers i.e. 30% in T2 and 50% in T3, whereas T4 received 100% Biofertilizers @ 100kg/acre. Different morphological parameters like length, branches/number, diameter, fresh weight, dry weight (all for both shoot and root), leaf surface area and fruit yield were observed at 35 DAS and 150 DAS. The application of 100% Biofertilizers dose was significantly beneficial in terms of fruit yield for both varieties (66.16±3.81 quintal/acre in hybrid and 52.02±4.73 quintal/acre in OP). Also the fresh and dry root weight was significantly higher in plant which received 100% Biofertilizers. Other parameters were found non-significant among all treatments. Shoot length and shoot branches were recorded maximum in OP plant which received T4 but it was equally highest for both T1 and T3 (shoot length) treated hybrid plant. Shoot diameter was found maximum for treatment T1 in case of OP variety but in case of hybrid it was recorded maximum and equal for both T1 & T4. Shoot fresh and dry weight was observed highest in T1 treated plant for both the varieties. Root length was found highest in T3 treated plant in case of hybrid variety but for To in OP variety. Root number was recorded highest in T1 treated plant for hybrid variety but T2 for OP variety. The overall finding revealed that most of the morphological traits and fruit yield were best in Biofertilizers treated plant.

KEYWORDS: Okra, Biofertilizers, Chemical Fertilizer, Open Pollinated, Hybrid, Vegetative Growth, Fruit Yield

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Original Article

INTRODUCTION

All parts of okra (Ladies' fingers) likes fresh leaves, buds, flowers, pods, stems and seeds can be used for different purpose and hence it is a multipurpose crop in term of its use (Gemede et al 2015). Okra is a powerhouse of valuable nutrients, nearly half of which is soluble fiber in the form of gums and pectins which help to lower serum cholesterol, reducing the risk of heart diseases. (http://thereadersbureau.com/okra-the-power-house-of-nutrients/). The mucilage found in okra may be used for plasma replacement or blood expender (Madison D 2008 and Maramag RP 2013). The seeds of okra contain 20-40 % oil and approx. 47% of which consists of Linoleic acid (MEF 2013 and Savello PA et al. 1980). The protein found in okra seeds are reach in essential amino acids (Farinde

A et al. 2007 and Siemonsma, J.S. , Hamon, C.S. 2002).

As the awareness about the organic products has increased among the people in last few years, its demand in the international market also indicate an upward trend and consumers are willing to pay a premium price for it against conventional products. Organic production and consumption have grown continuously over past decades. The statics report of different crops farming revealed that there is an emerging trend of organic agriculture. There are total 164 countries doing certified organic agriculture worldwide. In Asia, total 3.2 million hectare agricultural area was under organic agriculture during 2012, which contributed 9 percent of the world organic agriculture and India holed second position after China. According to FAOSTATE report 2011, the area under organic vegetable production was 0.4 % of the total area vegetable grown in world. The world leading countries under organic vegetable cultivation are United States, Mexico and Italy (The World of Organic Agriculture, Statics and Emerging trends, 2014. Research Instituted of Organic Agriculture and International Federation of Organic Agriculture Movements 2014). There is very good scope for production and commercialization of organic vegetable, especially lady finger. Lady finger is a crop responding to moderate dozes of organic manures. Biofertilizers can supplement the chemical fertilizers for meeting the nutrient needs and help in improving yield and quality of crop plants. A lot of study has been conducted time to time on okra to know the effect of organic, inorganic fertilizer and biofertilizers on growth and yield component. A greenhouse study conducted by Ufere N. Uka et al (2013) concluded that application of organic manure like cow dung and poultry manure gave better growth. It was reported by Vendan and Subramanian (1998) that dual inoculation of Azospirillum and phosphate solubilizing bacteria positively influence the yield in Oryza sativa. Combined application of Azospirillum and phosphate solubilizing bacteria had given higher grain yield in peal millet in a study conducted by Guggari and Kalaghatagi (2005). A lot of study conducted in last few years on the application of beneficial microbes for the high yield by sustainable means to overcome the harmful effect of chemical fertilizers. A study conducted by K. Padma Priya (2015) showed that the co-inoculation of Azospirillum and Phosphate solubilizing bacteria improved soil characters, plant growth and yield. Influenced by above works and its result, the present study was undertaken to evaluate yield and quality improvement along with soil nutrient availability.

MATERIALS AND METHODS

Study Site: An experiment to evaluate the effect of biofertilizers alone (recommended dose), reduced dose of chemical fertilizer with biofertilizers and recommended dose of chemical fertilizer on growth and yield on ladies finger was conducted for Open pollinated and Hybrid varieties during year 2015. The experiment site was located inside the campus of Patanjali Gramudyog, Haridwar, Uttarakhnad, India.

Experimental Design: A modified Random Block Design (RBD) was used for design of the experiment plots. Four treatments including one control were taken. Each treatment was replicated three times. The total extend of the land under cultivation was around 1260 m^2. Plot size was 42 m^2 (7 m x 6 m). Treatments were design as listed below in table 1 (quantity was taken as per recommended dose).

Table 1: Detail of Basal Treatments

Treatment	Combination
To	Control
T1	100 % chemical (DAP) @ 75 Kg/acre
T2	30 % Biofertilizers (Organic manure with microbial inoculum) @ 100 kg/acre +70 % chemical @ 75 Kg/acre
T3	50 % Biofertilizers @ 100 kg/acre +50 % chemical @ 75 Kg/acre
T4	Bio fertilizer @ 100 kg/acre + Composed cow dung @ 8 ton/acre
Composition	
Chemical:	Diammonium phosphate (DAP) 18% nitrogen and 46% P2O5.
Biofertilizers:	Carbon-24%, Nitrogen-2.25 %, Phosphorus-2.75 % , Potassium-1.775 %, Calcium-3%, Magnesium-0.45%, Sulphur-0.4%, Iron-0.6%, Zinc-0.35%, Manganese – 0.09% , Azotobacter sp., Trichoderma sp., Pseudomonas sp., Azospirillum sp., Bacillus megaterium

Treatment 1 (T1) received 100 % chemical fertilizer (DAP-IFFCO, India) whereas T4 received 100 % Biofertilizers (Patanjali Jaivik Khad-a product developed and marketed by Patanjali Bioresearch Institute). In treatment 2 (T2) 30 % of chemical fertilizer was replaced by biofertilizer whereas in T3 50% chemical fertilizer replaced by biofertilizer. The above treatment formulated aimed to evaluate a comparative effect of 100 % biofertilizer, 30% biofertilizers supplemented with 70% chemical fertilizer, 50% biofertilizers supplemented with 50% chemical fertilizer, 100 % chemical fertilizer on vegetative growth and fruit yield. Two types of varieties i.e. Open Pollinated (OP) and Hybrid were taken for this experiment. Seeds were treated with Bacillus megaterium (Phosphate Solubilizing Bacteria) + Rhizobium sp. + NPK @ 5 ml/kg seeds for 60 minutes before the sowing. Intermediate application of different treatments was applied 30 DAS and 60 DAS. Treatment T1 received Urea @ 25 kg/acre, treatment T2 and T3 received Urea @ 25 kg/acre + Humic acid @ 5 kg/acre + amino acid mixture @ 5 kg/acre whereas treatment T4 received liquid Potash @ 1.5 Liter/acre + Humic acid @ 5 kg/acre + amino acid mixture @ 5 kg/acre.

MEASUREMENT OF DATA

Soil Physicochemical Parameters:

Soil samples of each treatment were collected in triplicates, crushed, air-dried, and sieved with a 2-mm mesh size. The pH of samples was measured using a pH meter (Spectro, model SLE 2603, India) in a 2:5 (w/v) suspension. Nitrogen and Carbon was analyzed by using Spectrophotometric method by taking 1 gm sample in a 1:40 (w/v) solution. Potassium was measured as per Bray's method and Phosphorus as Merwin & Peach method.

Morphological and Growth Parameter (Morphology and Yield)

Morphological traits viz. plant height, shoot branches, fresh plant biomass, dry plant biomass, fresh root weight, dry root weight, number of leaves, leaves surface area, number of fruit per plant and total fruit yield per treatment etc were observed twice, first on 35 DAS (Days After Sowing) and second on 150 DAS (at the time of end harvest). Plant samples with intact roots were randomly taken from each treatment twice, first on 35 DAS and second on 150 DAS and washed with running tap water to removed soil particles that adhered on the roots and dried with blotting paper. Fresh plant biomass and fresh root weight was taken by separating shoot with root. For dry biomass determination, separate root and shoot were placed in the oven at 80°C until a constant weight was reached (The fresh and dry weight was measured as per described by Karl F. Wenger). The dried shoots and roots were then weighed separately, and biomass accumulation was expressed as grams per plant. Yield is expressed as fresh weight of fruits per treatment at the time of each harvest and

presented as weight/acre. Other growth parameters like plant height; fruit size, root size was measured in centimeter (cm) with the help of measuring scale. Also the number of leaves per plant was recorded. Data obtained from the experiments were subjected to one-way ANOVA test using the SPSS software (SPSS IBM) to assess the significance of differences mean values were separated using Tukey's test at 5% probability level. All data were presented as mean ± SE.

RESULTS AND DISCUSSIONS

Different soil parameters like pH, Electric conductivity, Soil moisture, Water holding capacity, and Nitrogen, Potassium, Phophorus and Organic carbon were analyzed before sowing (Table 2). Soil was found nearly neutral pH 6.78), low in organic carbon content (0.437 %), medium in total nitrogen 0.0437 %, very high in potassium content a (252.07 kg/acre) and low in available phosphorus (12.353 kg/acre).

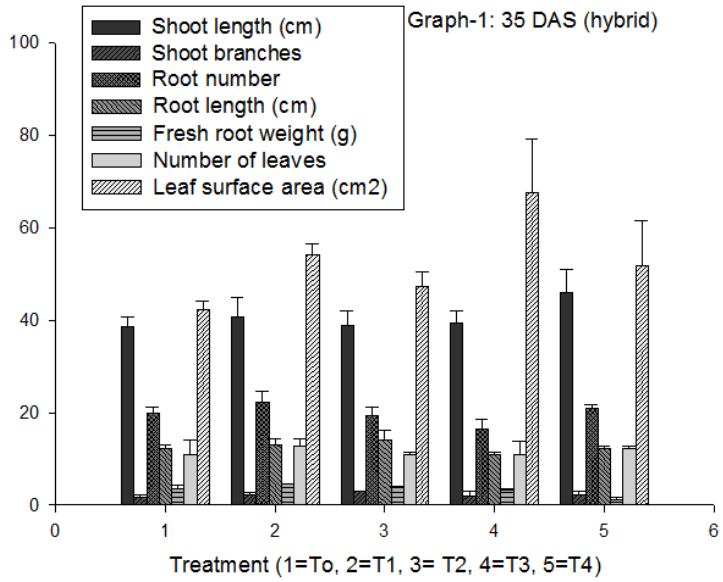
Table 2: Soil Physiochemical Detail

Type of Soil	Ph	Organic Carbon	Nitrogen	Potassium	Phosphorus
Sandy loam	6.77	0.437 %	0.0437 %	252.07 kg/acre	12.353 kg/ac

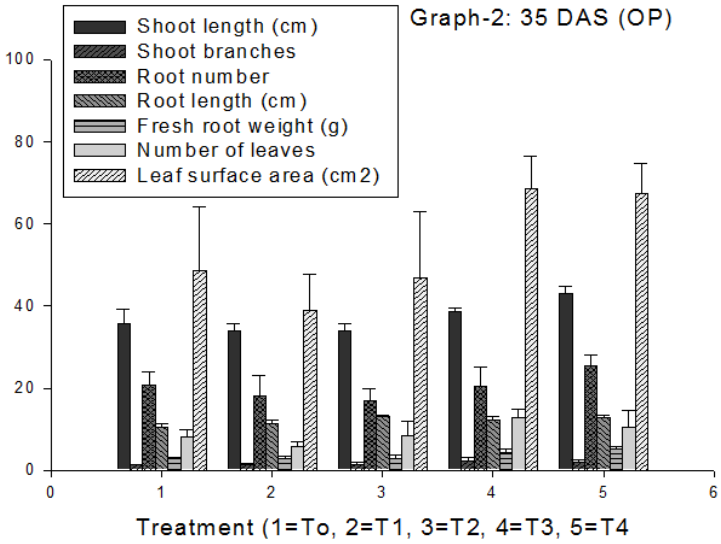
The responses of both varieties to various doses of treatments have been presented in table 3 (graph 1 & 2) and table 4 (graph 3 & 4) at 35 DAS and 150 DAS respectively. AT the time of first observation at 35 DAS, most of the morphological parameters were found maximum for treatment T1 in case of hybrid variety , but in case of OP variety it was found maximum for treatment T3 and T4 (Table 3) . The analysis revealed that shoot length was equal for 100 % and 70 % chemical treated plants but it increase with increasing organic input share and found highest for 100% biofertilizer treatment in both the varieties (46.13±4.78 cm for Hybrid and 43.18±1.47 cm for OP). No significant difference (p = 0.05) in shoot lengths had been observed as compared to untreated control plant. Also there was no significant difference (p = 0.05) in shoot branches among all treatments and it was highest for plant which received 100% chemical in case of hybrid variety (2.33±0.44) and for 50% organic + 50% chemical in case of OP variety (2.33±0.73). Maximum root number (22.17±2.40) was recorded for plant which received 100 % chemical in hybrid but in OP it was highest (25.33±2.67) for plant which received 100% organic inputs (i.e. biofertilizers). There was no any significant difference (p = 0.05) in root number among all treatments. Also there was no any significant difference observed for root length among all treatment, however, the longest root was recoded for plant grow with 70% chemical + 30 % organic for both varieties (13.97±2.21cm in hybrid and 13.13±0.43 cm in OP). Fresh root weight per plant was observed, show no any significant differences (p = 0.05) among all treatments with control, and found highest 4.45±0.14 g for hybrid plant which received 100 % chemical and 5.05±0.81 g for OP plant which received 100% organic. Leaf number was observed highest 12.67±1.64 in hybrid plant which received 100% chemical but it was maximum 12.83±1.92 for OP plant which received 50% organic + 50% chemical inputs, however, there was no significant difference (p = 0.05) observed among all treatments. Leaf area also not show any significant difference (p = 0.05) among all treatments and found highest for plant in which 50% organic + 50% chemical applied (67.74±11.38 cm^2 in hybrid and 68.58±7.78 cm^2 in OP).

The fruits were harvested at regular interval and the final morphological parameter was observed at 150 DAS (at the time of final harvest). The morphological parameters at 150 DAS were taken same as 35 DAS including shoot fresh weight, shoot and root dry weight, shoot diameter and total fruit yield but excluding leaf parameters (Table 4). In OP variety , the observed shoot length was highest (134.50±6.60 cm) for plant treated with 100% organic, same as 35 DAS, but in hybrid variety it was highest (108.33±3.33 cm) for both treatment 50 % organic + 50 % chemical and 100 % chemical against 100 % organic at 35 DAS, however, there was no significant difference (p = 0.05) observed among all treatments.

Graph 1: Response of treatments on different morphological traits of hybrid variety at 35 DAS.



Graph 2: Response of treatments on different morphological traits of OP variety at 35 DAS.



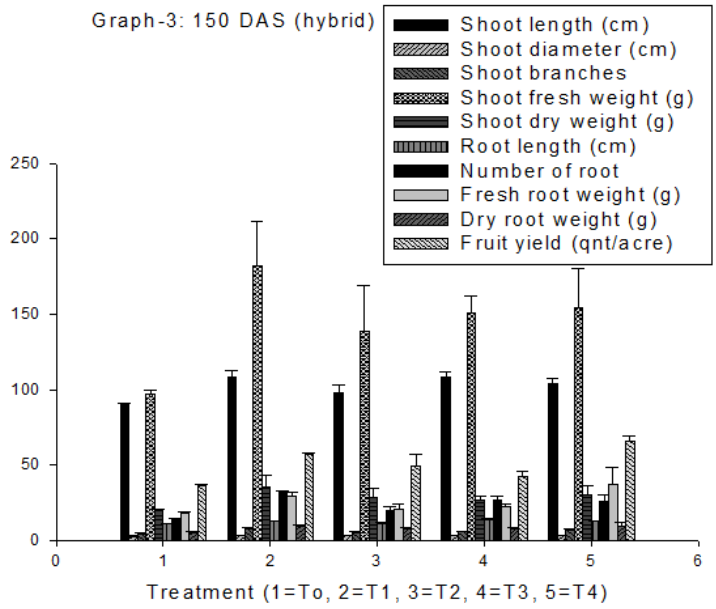
Shoot diameter was found maximum 3.00±0.29 cm for plant which received treatment 100% chemical in case of OP variety but it in case of hybrid it was observed highest and same for treatment either 100% organic (3.50±0.00 cm) or 100% chemical (3.50±0.00 cm), however, no significant difference (p = 0.05) was found between the all treatments. Highest number of shoot branches (7.50±1.60) was observed for plant which received 100% chemical in case of hybrid variety but was maximum for treatment either 100% organic (3.00 ± 0.29) or 50% organic + 50% chemical (3.00 ±1.0) in case of OP variety . The observed result for shoot branches show no significant difference (p = 0.05) among all treatments and followed the same trend as at 35 DAS. There was significance (p = 0.05) difference observed among the all treatments for shoot fresh weight and shoot dry weight, however, it was found highest for treatment with 100% chemical in both the varieties . In case of hybrid variety the maximum fresh shoot and dry shoot weight was 182.33±29.54 g and 35.83±7.44 g respectively, whereas, it was 188.67±7.20 g and 31.43±4.1g respectively in case of OP variety. The observed data for root length at 150 DAS was different from 35 DAS data. It was highest for treatment 70% chemical + 30% organic at 35 DAS,

whereas it was found maximum for treatment 50% organic + 50% chemical in case of hybrid (14.00±50 cm) and for control in case of OP (14.17 ± 0.83), at the time of 150 DAS. There was no significant difference (p = 0.01 or 0.05) observed among all treatments in case of OP variety , but in case of hybrid variety , all treatment (except 30% organic + 70% chemical) ware significantly higher than control. The treatment with 50% organic + 50% chemical was significantly higher than control and treatment with 30% organic +70% chemical at p = 0.01, whereas treatment with either 100% chemical or with 100% organic were significantly higher than control and treatment with 30% organic +70% chemical at p= 0.05. The maximum root number (31.83±1.17) was observed in hybrid plants which received 100% chemical, whereas, it was recorded maximum in OP plant which received 30% organic + 70% chemical. There was no significant difference (p = 0.01 or 0.05) observed among all treatments in case of OP variety , but in case of hybrid variety , all treatment (except 30% organic + 70% chemical) ware significantly higher than control. Treatment with 100% chemical found significant with control at p = 0.01, whereas the treatment with 100% organic found significantly higher than control at p = 0.05. The maximum root weight (fresh and dry) was observed for the plant which received 100% organic in both the varieties (fresh root weight 37.00±11.53 g in hybrid, 34.33±22.92 g in OP; dry root weight 9.93±2.45 g in hybrid, 7.38±3.98 g in OP), however, there was no significant difference (p = 0.05) observed among all treatments. Total fruits yield per treatment were found significantly highest (with respect to control) for the plant which received 100% organic inputs (Biofertilizers) in both the varieties. There was no significant difference found among three treatments (T1, T2 and T3). The highest fruit yield 66.16 ± 3.81 quintal/acre was recorded in case of hybrid variety whereas it was 52.02±4.73 quintal/acre in OP variety.

Table 3: Growth Attributing Characters of Okra Influenced by Bio and Chemical Fertilizers at 35 DAS. Values Are Means ± SE

	Treatment									
	To		T1		T2		T3		T4	
	Hybrid	OP	Hybrid	OP	Hybrid	OP	Hybrid	OP	Hybrid	OP
Shoot length (cm)	38.51±2.11	35.56±3.66	40.64±4.39	33.86±1.85	38.94±3.05	33.86±1.85	39.37±±2.54	38.53±0.84	46.13±4.78	43.18±1.47
Shoot branches plant^{-1}	1.66±0.44	1.33±0.17	2.33±0.44	1.33±0.33	1.00±0.00	1.50±0.50	2.00±1.00	2.33±0.73	2.17±0.73	1.83±0.83
Number of root plant^{-1}	19.83±1.42	20.67±3.37	22.17±2.40	18.00±5.03	19.33±1.74	17.00±2.75	16.50±2.02	20.33±4.79	20.83±.93	25.33±2.67
Root length (cm)	12.27±0.84	10.59±0.84	13.11±1.12	11.43±0.74	13.97±2.21	13.13±0.43	10.99±0.44	12.27±0.84	12.27±0.44	12.7±0.74
Fresh root weight (g) plant^{-1}	3.46±0.92	2.85±0.33	4.45±0.14	2.90±0.40	3.7±0.29	2.85±0.81	3.17±0.42	4.33±0.92	4.26±0.32	5.05±0.81
Number of leaves plant^{-1}	11.00±3.12	8.17±1.69	12.67±1.64	5.67±1.20	10.83±0.73	8.50±3.32	11.00±2.78	12.83±1.92	12.33±0.44	10.33±4.34
Leaf area (cm^2)	42.34±1.70	48.69±15.55	54.18±2.24	38.94±8.84	47.42±3.10	46.99±16.09	67.74±11.38	68.58±7.78	51.82±9.76	67.31±7.45

Graph 3: Response of treatments on different morphological traits of hybrid variety at 150 DAS.



Graph 4: Response of treatments on different morphological traits and yield of OP variety at 150 DAS.

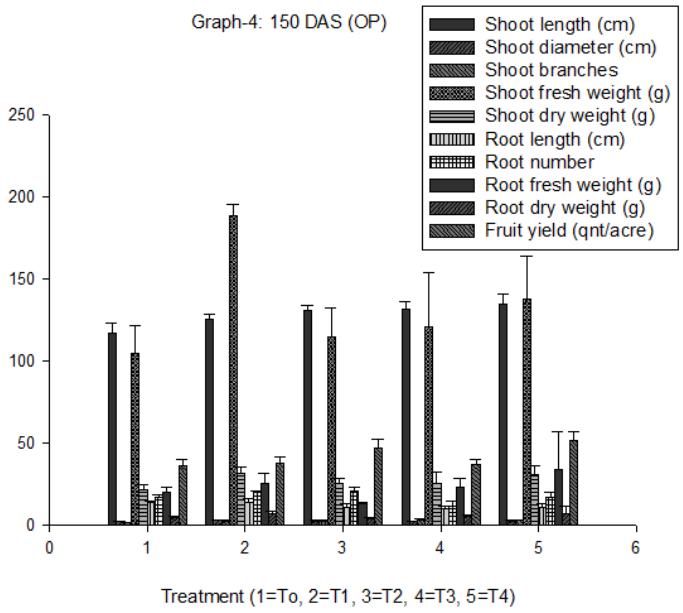


Table 4: Growth and Yield Attributing Characters of Okra Influenced by Bio and Chemical Fertilizers at 150 DAS. Values Are Means ± SE

	Treatment									
	To		T1		T2		T3		T4	
	Hybrid	OP	Hybrid	OP	Hybrid	OP	Hybrid	OP	Hybrid	OP
Shoot length (cm)	90.00±1.44	116.83±6.83	108.33±4.41	125.83±2.9	98.33±4.41	131.17±2.71	108.33±3.33	131.67±4.41	104.17±3.33	134.50±6.60
Shoot diameter (cm) plant^{-1}	3.00±0.29	2.33±0.44	3.50±0.00	3.00±0.29	3.33±0.17	2.83±0.17	3.33±0.167	2.25±0.14	3.50±0.00	2.83±0.17
Shoot branches plant^{-1}	4.67±0.93	1.67±0.33	7.50±1.60	2.83±0.73	5.33±1.20	2.17±0.93	6.00±0.50	3.00±1.00	7.17±0.44	3.00±0.29
Shoot Fresh weight (g) plant^{-1}	97.00±3.06	105.00±16.62	182.33±29.54	188.67±7.20	138.33±30.94	114.50±18.25	150.50±12.00	121.00±33.02	154.17±25.78	137.67±26.76
Shoot dry weight (g) plant-1	19.78±0.72	21.60±3.08	35.83±7.44	31.43±4.11	28.51±6.13	25.35±3.03	26.75±2.77	25.38±7.46	30.70±6.20	31.35±5.21
Root length (cm)	11.33±0.167	14.17±0.83	13.50±0.00	13.83±2.85	11.17±0.67	11.00±2.02	14.00±.50	10.35±1.47	13.17±0.17	11.00±2.29
Number of root plant^{-1}	13.67±0.73	17.17±1.48	31.83±1.17	20.00±1.32	20.33±2.04	21.33±1.85	27.17±2.40	11.83±3.00	26.00±4.61	17.17±3.28
Fresh root weight (g) plant^{-1}	18.33±0.60	20.00±3.51	29.67±2.60	25.33±6.17	20.67±3.33	13.17±0.93	22.33±1.85	23.50±5.39	37.00±11.53	34.33±22.92
Dry root weight (g) plant^{-1}	5.50±0.40	5.05±0.76	9.48±0.67	7.10±1.39	7.52±1.31	4.28±0.16	8.03±0.68	5.60±1.00	9.93±2.45	7.38±3.98

The similar result (yield) of the study was well agreed with previous finding of many experiment conducted by different scientist. A similar result observed by Ponnuswamy et al., (2002) who reported that a combination of phosphorbacteria and Azospoirillum had a positive effect on yield and yield characters. Also a similar study were conducted by Olaniyi, J.O et al (2010) in the year of in 2005 and 2006 and found that organic fertilizer better in term of growth and yield in okra. During the year 2011, a field experiment was conducted by M. G. Kibria et al (2013) showed that the combined application of 50% chemical fertilizer + 50% organic input gave best performance in terms of yield. Barnali Mal (2014) conducted a field experiment in the year 2010 and 2011 concluded that application of biofertilizers along with recommended dose of NPK would be beneficial in terms of vegetative growth, fruit yield and economic in okra. Also Inderjeet Sharma et al (2014) agreed that application of biofertilizers like Azospirillum, Azotobacter and Phosphorus solubilizing bacteria with interaction with fertilizer had influence on growth and yield attribute in okra.

CONCLUSIONS

Most of the morphological parameters like shoot length, shoot branches, shoot diameter were found highest in 100% organic and 100% chemical (Figure 1: a to f). Fresh and dry root weight and the overall yield was found highest in 100 % organic treatment. The above finding clearly revealed that the vegetative growth was very similar in both 100% organic combination and 100% chemical. The finding of study concluded that using combined application of organic manure along with biofertilizers had a maximum impact on fruit yield.

Figure 1: (a)-Cultivated Site, (b)-Crop at 35 DAS, (c)-Crop at 150 DAS, (d)-Fruit at 150 DAS (e) - Root at 35 DAS, (f) - Root at 150 DAS

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